ULTRASONIC SURGICAL SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an ultrasonic surgical system for treating a living tissue using ultrasonic waves output from an ultrasonic transducer incorporated in a handpiece.

2. Description of the Related Art

As surgical operation apparatuses taking over an electric cautery, various types of operation apparatuses utilizing ultrasonic waves, for example, an ultrasonic knife unit and an ultrasonic trocar-and-cannula unit described in Japanese Unexamined Patent Publication No. 9-38098 have been proposed and widely spread in the past.

This sort of ultrasonic surgical apparatus has a handpiece, in which an ultrasonic transducer is incorporated, connected to a main unit having a driving signal generator for generating an ultrasonic driving signal and a control unit. The ultrasonic transducer is driven to oscillate using the driving signal output from the main unit, whereby ultrasonic waves are generated. The generated ultrasonic waves are propagated into a treatment unit incorporated in the distal part of the handpiece. The treatment unit is pressed against a region to be treated, whereby a living

tissue is treated.

For treating a living tissue using the ultrasonic surgical apparatus, the treatment unit in the handpiece is abutted on a region to be treated in a living tissue. In this state, a foot switch is turned on or off in order to activate or inactivate the treatment unit, that is, to control driving of the driving signal generator in the main unit.

However, for performing a complex operation, since various types of operation equipment are used, many foot switches are placed in an operating room. An operator must therefore be so careful as not to press an incorrect foot switch. This annoys the operator.

Moreover, depending on the contents of an operation or a treating procedure, a plurality of different handpieces must be used during one operating procedure. Some handpieces can therefore be selected and connected to the main unit of an ultrasonic surgical apparatus. The handpieces are changed depending on a purpose of use and thus used for different purposes.

One main unit has one handpiece connector. For using different handpieces, the connectors must be changed and a selected connector must be connected to the main unit every time it is needed. It is a nuisance to have to change the connectors and connect a selected one during, especially, an

operation. Besides, extra time is needed. This drawback has been requested to be overcome by operators who give emergency medical services. Otherwise, a plurality of main units may be prepared, and necessary handpieces may be connected to the main units in advance. It is uneconomic to prepare the same number of main units as the number of necessary types of handpieces. Besides, an unnecessarily wide space is occupied. Moreover, an operator must check which of the plurality of handpieces arranged near a region to be operated is now usable before activating the handpiece. This annoys the operator.

Furthermore, it is conceivable to connect a plurality of handpieces to one main unit. In this case, a switching device is required for switching the connected handpieces. When the switching device is operated using the main unit, since the main unit is located in an unclean area in an operating room, an operator cannot handle the switching device. The operator must therefore ask a nurse or the like to handle the switching device. It becomes a nuisance to have to switch the handpieces.

Furthermore, handpieces of different types include a handpiece capable of sucking a fluid or the like. The handpiece has a perfusion channel and a suction channel formed therein. The perfusion channel is used to supply physiological saline with which a treated region is washed

or cooled, while the suction channel is used to pulverize a tissue using ultrasonic waves, and then suck and remove the pulverized tissue fragments together with physiological saline from the treatment unit. For using the handpiece, a perfusing means and a sucking means must be incorporated in the main unit. In addition, a perfusion tube and a suction tube are needed for linking the means and the handpiece.

SUMMARY OF THE INVENTION

An object of the present invention is to provide an ultrasonic surgical system offering improved maneuverability of handpieces and relieving an operator's annoyance. The ultrasonic surgical system makes it possible to activate or inactivate an ultrasonic transducer in a handpiece using a hand switch aside from a foot switch.

Another object of the present invention is to provide an ultrasonic surgical system enabling connection of a plurality of handpieces to one main unit without the necessity of retrofitting the main unit. Even when a plurality of handpieces is needed for an operation, it is unnecessary to prepare a plurality of main units in an operating room.

Still another object of the present invention is to provide an ultrasonic surgical system offering improved maneuverability. The ultrasonic surgical system makes it

possible to activate or inactivate respective handpieces connected to a main unit, and to use the plurality of connected handpieces for different purposes.

According to the present invention, there is provided an ultrasonic surgical system having a main unit that includes a driving signal generator, an output unit, a manipulation signal sense unit, a control unit, and a manipulation signal input unit. The driving signal generator generates a driving signal used to drive and oscillate an ultrasonic transducer in a handpiece. The output unit outputs a driving signal generated by the driving signal generator and destined for the ultrasonic transducer in the handpiece. The manipulation signal sense unit senses an input manipulation signal. The control unit controls the driving signal generator according to the manipulation signal sensed by the manipulation signal sense unit. The manipulation signal input unit inputs the manipulation signal. Ultrasonic waves stemming from the ultrasonic transducer incorporated in the handpiece are transmitted in order to operate a living tissue.

The ultrasonic surgical system includes an extension unit having an input unit for inputting the manipulation signal with a hand switch, which produces the manipulation signal, connected thereto, and an input unit for inputting the manipulation signal with a foot switch, which produces

the manipulation signal, connected thereto. The extension unit also includes an output unit for outputting the manipulation signal input to the input unit and based on a manipulation performed on the hand switch or the foot switch to the manipulation signal input unit in the main unit.

Moreover, according to the present invention, there is provided an ultrasonic surgical system having a main unit that includes a driving signal generator, an output unit, a manipulation signal sense unit, a control unit, and a manipulation signal input unit. The driving signal generator generates a driving signal used to drive and oscillate an ultrasonic transducer in a handpiece. The output unit outputs a driving signal generated by the driving signal generator and destined for the ultrasonic transducer in the handpiece. The manipulation signal sense unit senses an input manipulation signal. The control unit controls the driving signal generator according to the manipulation signal sensed by the manipulation signal sense unit. The manipulation signal input unit inputs the manipulation signal. Ultrasonic waves stemming from the ultrasonic transducer incorporated in the handpiece are propagated in order to operate a living tissue.

The ultrasonic surgical system has an extension unit including an input unit for inputting a driving signal, a plurality of output units, a switching unit, an input unit

for inputting a manipulation signal, and an output unit. The input unit for inputting a driving signal is connected to the driving signal output unit in the main unit. The plurality of output units outputs the driving signal input to the driving signal input unit to ultrasonic transducers in a plurality of handpieces. The switching unit switches the plurality of output units to select an output unit for outputting a driving signal. The input unit for inputting a manipulation signal has at least one of a hand switch and a foot switch, which generate the manipulation signal, connected thereto. The output unit outputs the signal input to the manipulation signal input unit to the manipulation signal input unit in the main unit.

Furthermore, according to the present invention, there is provided an ultrasonic surgical system having a main unit that includes a driving signal generator, an output unit, a manipulation signal sense unit, a control unit, and a manipulation signal input unit. The driving signal generator generates a driving signal used to drive and oscillate an ultrasonic transducer in a handpiece. The output unit outputs a driving signal generated by the driving signal generator and destined for the ultrasonic transducer in the handpiece. The manipulation signal sense unit senses an input manipulation signal. The control unit controls the driving signal generator according to the

manipulation signal sensed by the manipulation signal sense unit. The manipulation signal input unit inputs the manipulation signal. Ultrasonic waves stemming from the ultrasonic transducer incorporated in the handpiece are propagated in order to operate a living tissue.

The ultrasonic surgical system has an extension unit including an input unit for inputting a driving signal, a plurality of output units, a switching unit, an input unit for inputting a manipulation signal, and an output unit. The input unit for inputting a driving signal is connected to the driving signal output unit in the main unit. The plurality of output units outputs the driving signal input to the driving signal input unit to ultrasonic transducers in a plurality of handpieces. The switching unit switches the plurality of output units to select an output unit for outputting a driving signal. The input unit for inputting a manipulation signal is connected to at least one of a hand switch and a foot switch that produces the manipulation signal. The output unit outputs the signal input to the manipulation signal input unit to the manipulation signal input unit in the main unit.

Furthermore, according to the present invention, a perfusing means, a sucking means, and a communicating and controlling means are included. The perfusing means supplies a fluid to a handpiece through a perfusion tube.

The sucking means sucks a pulverized tissue and a fluid from the handpiece through a suction tube. The communicating and controlling means allowing the main unit and extension unit to communicate with each other and give control so that when an ultrasonic suction handpiece is selected, at least one of said perfusing means and sucking means will be actuated synchronously with output of ultrasonic waves.

Other features and advantages of the present invention will be fully apparent from the description below.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an explanatory diagram schematically showing the configuration of an ultrasonic surgical system in accordance with the first embodiment of the present invention;

FIG. 2A and FIG. 2B are explanatory diagrams showing second and third handpieces to be selectively connected to a main unit instead of a scissors-like handpiece shown in FIG. 1;

FIG. 2A shows the appearance of a hook-like handpiece that is the second handpiece;

FIG. 2B shows the appearance of a trocar and cannula-like handpiece that is the third handpiece;

FIG. 3 is a circuit block diagram showing circuits included in a hand switch, a foot switch, an extension unit,

and a main unit;

FIG. 4 is a circuit block diagram for explaining another applied example of circuits different from those shown in FIG. 3;

FIG. 5 is an explanatory diagram schematically showing the configuration of an ultrasonic surgical system in accordance with the second embodiment of the present invention;

FIG. 6 is a circuit block diagram showing the ultrasonic surgical system shown in FIG. 5;

FIG. 7 to FIG. 9 relate to the third embodiment;

FIG. 7 is an explanatory diagram schematically showing the configuration of an ultrasonic surgical system;

FIG. 8 is a circuit block diagram showing the ultrasonic surgical system shown in FIG. 7;

FIG. 9 is a circuit block diagram showing a modification of a perfusion/suction unit shown in FIG. 8;

FIG. 10 is an explanatory diagram schematically showing the configuration of an ultrasonic surgical system in accordance with the fourth embodiment of the present invention;

FIG. 11 shows the appearance of a handpiece having a built-in hand switch used when selected instead of a scissors-like handpiece shown in FIG. 10;

FIG. 12 is a circuit block diagram of the ultrasonic

surgical system shown in FIG. 10;

FIG. 13 is an explanatory diagram schematically showing an ultrasonic surgical system in accordance with the fifth embodiment of the present invention;

FIG. 14 is a circuit block diagram of the ultrasonic surgical system shown in FIG. 13;

FIG. 15 is a flowchart describing a sequence of selecting a connector of an extension unit shown in FIG. 10; and

FIG. 16A, FIG. 16B, and FIG. 16C are explanatory diagrams showing the internal wirings of hand switches.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 to FIG. 4 relate to the first embodiment of the present invention. FIG. 1 is an explanatory diagram schematically showing the configuration of an ultrasonic surgical system having a scissors-like handpiece, which is a first handpiece, connected to a main unit so that the handpiece can be unconnected freely. FIG. 2A and FIG. 2B are explanatory diagrams showing second and third handpieces connected to the main unit when selected instead of the scissors-like handpiece shown in FIG. 1. FIG. 2A shows the appearance of a hook-like handpiece that is the second handpiece, while FIG. 2B shows the appearance of a trocar and cannula-like handpiece that is the third handpiece. FIG.

3 is a circuit block diagram showing circuits incorporated in the hand switch, a foot switch, an extension unit, and the main unit which are shown in FIG. 1. FIG. 4 is a circuit block diagram for explaining another applied example of circuits different from those shown in FIG. 3.

An ultrasonic surgical system 1 of the present embodiment has, as an ultrasonic surgical apparatus 1A, a main unit 2, a scissors-like handpiece 3A, a hand switch 4, a foot switch 5, and an extension unit 6. The main unit 2 has a driving signal generator, which is used to drive an ultrasonic transducer that is not shown, incorporated therein. The scissors-like handpiece 3A is connected to the main unit 2 and serves as the first handpiece having an ultrasonic transducer, which is not shown, incorporated therein. The hand switch 4 is detachably attached to the scissors-like handpiece 3A. The foot switch 5 is selectively manipulated instead of the hand switch 4. The extension unit 6 has a manipulation signal generator for detecting an on-state or off-state signal stemming from the hand switch 4 or foot switch 5 and producing a manipulation signal, and a connector used to transmit the signal to the main unit 2.

A handpiece connector portion 9, a power switch 10, and a display panel 11 are arranged on a front panel 7 of the main unit 2. A handpiece connector 8a of the scissors-like

handpiece 3A that is the first handpiece is freely detachably attached to the handpiece connector portion 9. The power switch 10 is used to turn on or off the power supply of the main unit. The display panel 11 displays the moving situation of the scissors-like handpiece 3A. When a handpiece connector 8a linked to the scissors-like handpiece 3A is freely detachably attached to the handpiece connector portion 9, the main unit 2 enables ultrasonic treatment. A joint connector portion 13 to which a joint connector 12 linked to the extension unit 6 is joined is formed on the back of the main unit 2 (see FIG. 3). Aside from the handpiece connector 8a linked to the scissors-like handpiece 3A that is the first handpiece, a handpiece connector 8b linked to a hook-like handpiece 3A shown in FIG. 2A and a handpiece connector 8c linked to a trocar and cannula-like handpiece 3C shown in FIG. 2B can be selectively attached to the handpiece connector portion 9.

The scissors-like handpiece 3A that is the first handpiece consists of an elongated sheath 14a, a handy operation unit 15a coupled to the proximal end of the sheath 14a, and a treatment unit 16a located in the distal part of the sheath 14a.

An ultrasonic transducer for generating ultrasonic waves, which is not shown, and a prove 17 for propagating the ultrasonic waves stemming from the ultrasonic transducer

to the treatment unit 16a are incorporated in the scissors-like handpiece 3A. The treatment unit 16a has a clamping portion 18 supported so as to freely pivot at the distal end of the sheath 14a. The clamping portion 18 can be brought into contact with or separated from the distal part of the probe 17. The operation unit 15a has a stationary handle 19a and a movable handle 20a. The movable handle 20a is opened or closed relative to the stationary handle 19a, whereby the clamping portion 18 of the treatment unit 16a can be brought into contact with or separated from the distal part of the probe 17. In this case, when the movable handle 20a is closed, the clamping portion 18 is turned in a direction in which the clamping portion 18 is closed relative to the distal part of the probe 17. The clamping portion 18 and the distal part of the probe 17 cooperate with each other in clamping a living tissue such as a blood vessel in a living body. In this state, the ultrasonic transducer in the scissors-like handpiece 3A is driven in order to ultrasonically coagulate or incise the living tissue clamped by the probe 17 and clamping portion 18.

The hand switch 4 is detachably attached to the handy operation unit 15a of the scissors-like handpiece 3A. The hand switch 4 consists of, for example, two switches A and B, and has a hand switch connector 21 linked to the proximal end thereof. The hand switch connector 21 is joined to the

extension unit 6. Likewise, the foot switch 5 consists of two pedal switches A and B used to control activation or inactivation of the ultrasonic transducer, and has a foot switch connector 22 linked thereto. The foot switch connector 22 is joined to the extension unit 6.

The hook-like handpiece 3B that is the second handpiece shown in FIG. 2A has a treatment unit 16b, which is different from that of the scissors-like handpiece 3A, attached to a sheath 14b thereof. Similarly to the scissors-like handpiece 3A that is the first handpiece, the hand switch 4 is detachably attached to the flank of an operation unit 15b of the hook-like handpiece 3B.

The treatment unit 16b of the hook-like handpiece 3B has a substantially L-shaped receptor 23 fixed to the distal end of the sheath 14b, and an abutment member 24 capable of sliding in axial directions in the sheath 14b. The distal part of a probe that is not shown is coupled to either the receptor 23 or abutment member 24.

A movable handle 20b is opened or closed relative to a stationary handle 19b of the operation unit 15b, whereby the abutment member 24 of the treatment unit 16b can be brought into contact with or separated from the receptor 23. In this case, when the movable handle 20 is closed, the abutment member 24 of the treatment unit 16b is slid to abut on the receptor 23. The abutment member 24 and receptor 23

cooperate with each other in clamping a living tissue, for example, a blood vessel of a living body. The ultrasonic transducer in the hook-like handpiece 3B is driven in this state, whereby the living tissue clamped by the abutment member 24 and receptor 23 is treated ultrasonically.

A trocar and cannula-like handpiece 3C shown in FIG. 2B, which is the third handpiece, does not resemble the scissors-like handpiece 3A and hook-like handpiece 3B. Specifically, the trocar and cannula-like handpiece 3C has the ability to mechanically oscillate a needle connected to the ultrasonic transducer that is not shown and thus cause the needle to pierce the wall of a body cavity.

The trocar and cannula-like handpiece 3C consists of an elongated needle 25, an armor 27, a handy operation unit 15c, and a treatment unit 16c. The needle 25 pierces the wall of a body cavity while propagating oscillatory energy produced by the ultrasonic transducer. The armor 27 has a guide hole 26 through which the needle 25 is passed. The operation unit 15c is coupled to the proximal end of the needle 25. The treatment unit 16c is the proximal part of the needle 25.

The hand switch 4 is detachably attached to the operation unit 15c of the handpiece 3C similarly to that of the scissors-like handpiece 3A that is the first handpiece.

The trocar and cannula-like handpiece 3C is used after the epidermis of the wall of a body cavity is a little

incised using a knife of the like. Specifically, the treatment unit 16c of the trocar and cannula-like handpiece 3C is thrust into the wall of a body cavity. The needle 25 is oscillated using the ultrasonic transducer, whereby the needle applies piercing force to the wall of a body cavity together with the armor 27 mated with the needle due to the guide hole 26. The needle 25 is thus thrust forward to pierce a tissue. After the armor 27 is also thrust into the tissue, the needle 25 is withdrawn with the armor 27 thrust into the wall of a body cavity. An endoscope that is not shown or any other treatment appliance is then inserted into the guide hole 26 of the armor 27 in order to observe or operate a lesion.

The extension unit 6 has a hand switch connector portion 28 formed on the front side thereof. The hand switch connector 21 linked to the hand switch 4 is joined to the hand switch connector portion 28. The extension unit 6 has a foot switch connector portion 29 formed on the back side thereof (see FIG. 3). The foot switch connector 22 linked to the foot switch 5 is joined to the foot switch connector portion 29. The extension unit 6 has the joint connector 12 linked thereto. A signal produced by the manipulation signal generator incorporated in the extension unit 6 is transmitted to the main unit 2 through the joint connector 12. The hand switch 4 is connected to the main

unit 2 via the extension unit 6. When either the switches A and B of the hand switch 4 is pressed, the movement of, for example, the selected and connected scissors-like handpiece 3A that is the first handpiece can be controlled.

In the present embodiment, when the extension unit 6 is connected to the main unit 2, the hand switch 4 as well as the foot switch 5 can be connected to the main unit without the necessity of retrofitting the main unit 2. Consequently, an operator would enjoy improved maneuverability.

Referring to FIG. 3, a description will be made of the circuitry of the ultrasonic surgical system consisting of the hand switch 4 and foot switch 5, the extension unit 6 to which the connectors linked to the hand switch 4 and foot switch 5 are joined, and the main unit 2 to which the extension unit 6 is connected. To begin with, the circuitry of the main unit 2 will be described below.

The main unit 2 consists mainly of a switch sense circuit 31, a control unit 32, and an oscillator circuit 33. The switch sense circuit 31 detects a signal sent from the foot switch 5 or hand switch 4 via the extension unit 6. The control unit 32 outputs a control signal according to a signal output from the switch sense circuit 31. The oscillator circuit 33 drives the handpiece according to the control signal output from the control unit 32. The main unit 2 has the joint connector portion 13 to which the joint

connector 12 linked to the extension unit 6 is joined, and the connector portion 9 to which the handpiece connectors 8a, 8b, and 8c linked to the first to third handpieces are joined selectively. Incidentally, the foot switch connector 22 linked to the foot switch 5 may be joined directly to the main unit 2. In this case, the switch sense circuit 31 in the main unit 2 can receive a signal stemming from either of the two pedal switches A and B of the foot switch 5 which is stepped on.

The hand switch 4 consists of, for example, the aforesaid two switches A and B, and has the hand switch connector 21 linked thereto. The hand switch connector 21 accommodates a line linking a contact 34a of the switch A and a contact 34b of the switch B, a line linked to a contact 35a of the switch A, and a line linked to a contact 35b of the switch B.

When the switch A of the hand switch 4 is pressed, the contacts 34a and 35a of the switch A mutually conduct and conduct electricity to the extension unit 6 via the hand switch connector 21. When the switch B is pressed, the contacts 34b and 35b of the switch B mutually conduct and conduct electricity to the extension unit 6 via the hand switch connector 21.

The foot switch 5 consists of, for example, the aforesaid two pedal switches A and B. The circuitry of the

foot switch is analogous to that of the hand switch 4. Specifically, a contact 36a of the pedal switch A and a contact 36b of the pedal switch B are linked, and a contact 37a of the pedal switch A and a contact 37b of the pedal switch B are linked.

The manipulation signal generator of the extension unit 6 consists mainly of, for example, a circuit composed of one OR gate OR1 of an OR circuit 38 and an analog switch SW1 and a circuit composed of the other OR gate OR2 of the OR circuit 38 and an analog switch SW2. The analog switch SW1 opens or closes based on an output of the OR gate OR1. The analog switch SW2 opens or closes based on an output of the OR gate OR2. As mentioned previously, the extension unit 6 has the hand switch connector portion 28, the foot switch connector portion 29, and the joint connector 12. The hand switch connector 21 of the hand switch 4 is joined to the hand switch connector portion 28. The foot switch connector 22 of the foot switch 5 is joined to the foot switch connector portion 29. The joint connector 12 serves as a connecting means for connecting the extension unit to the main unit 2.

Among three lines accommodated by the hand switch connector portion 28 of the extension unit 6, the first line is linked to a voltage source +V used to bring a signal to a high level and to the foot switch connector portion 29 to

which the foot switch connector 22 is joined. The second line is linked to the OR gate OR1. The third line is linked to the OR gate OR2.

The same applies to the foot switch connector portion 29. The first line is linked to the voltage source +V used to bring a signal to a high level and to the hand switch connector portion 28 to which the hand switch connector 21 is joined. The second line is linked to the OR gate OR1, and the third line is linked to the OR gate OR2.

The output terminal of the OR gate OR1 is connected to the analog switch SW1. The output terminal of the OR gate OR2 is connected to the analog switch SW2. The node between the OR gate OR1 and analog switch SW1 and the node between the OR gate OR2 and analog switch SW2 are grounded via a resistor R1 and a resistor R2 respectively. When the switch A or B of the hand switch 4 is not pressed or the switch A or B of the foot switch 5 is not stepped on, the output terminal of the OR gate OR1 or OR gate OR2 is low.

A contact a of the analog switch SW1 is connected to a contact A of the joint connector 12. A contact b thereof is connected to a contact COM of the joint connector 12. A contact a of the analog switch SW2 is connected to a contact B of the joint connector 12, and a contact b thereof is connected to the contact COM of the joint connector 12.

When the hand switch 4 is pressed or the foot switch 5

is stepped on, either the hand switch 4 or foot switch 5 conducts. Either of the two OR gates OR1 and OR2 becomes active via the hand switch connector 21 of the hand switch 4 or the foot switch connector 22 of the foot switch 5. Either the analog switch SW1 or analog switch SW2 is turned on and conducts electricity to the switch sense circuit 31 in the main unit via the contacts A and COM of the joint connector 12 or the contacts B and COM thereof. More particularly, when the switch A of the hand switch 4 is pressed, the contact 34a and contact 35a of the switch A conduct to go high due to the voltage source +V in the extension unit. This causes the OR gate OR1 to conduct. The analog switch SW1 makes an on-to-off transition. When the analog switch SW1 is turned on, the analog switch SW1 conducts electricity to the contacts A and COM of the joint connector 12. The switch A of the hand switch 4, the OR gate OR1 of the extension unit 6, the analog switch SW1, and the contacts A and COM of the joint connector 12 constitute a closed circuit. Consequently, the switch sense circuit 31 senses that the switch A of the hand switch 4 has been pressed. The extension unit 6 may be designed to deal with the hand switch 4 or foot switch 5 as a top priority or to deal with a switch manipulated first as a top priority.

When the ultrasonic surgical apparatus 1A having the foregoing components is employed, the scissors-like

handpiece 3A that is the first handpiece is controlled with the treatment unit 16a of the scissors-like handpiece 3A abutted on a region to be treated in a living tissue.

For example, when the switch A or B of the hand switch 4 is pressed, a manipulation signal indicating that the hand switch 4 has been manipulated is transmitted to the extension unit 6. An output of the extension unit 6 is transmitted to the switch sense circuit 31 in the main unit 2. It is then sensed which of the switches has been pressed. Based on a sensed signal, the control unit 32 gives control to activate or inactivate the oscillator circuit 33. An output of the oscillator circuit 33 is transmitted to the scissors-like handpiece 3A via the handpiece connector 3a. With the output, output of ultrasonic waves is enabled or disabled.

Consequently, even when the ultrasonic surgical apparatus 1A is designed to permit use of the foot switch 5 alone, the hand switch 4 is usable. This leads to improved user-friendliness.

The hand switch 4 described in conjunction with FIG. 3 and the main unit 2 conduct mutually. For example, when a patient's living tissue is treated with the treatment unit 16a of the scissors-like handpiece 3A abutted on a region to be treated, there is a fear that electricity may be conducted to the living tissue via the hand switch 4.

A circuit for electrically separating a hand switch 41 from a foot switch 42 may be, as shown in FIG. 4, included in an extension unit 43. To begin with, the hand switch 41 and foot switch 42 will be described below.

The hand switch 41 consists, like the one shown in FIG. 3, of two switches A and B. A hand switch connector 45 is linked to the hand switch 41. The hand switch connector 45 accommodates a line linking a contact 43a of the switch A and a contact 43b of the switch B, a line linked to a contact 44a of the switch A, and a line linked to a contact 44b of the switch B.

The foot switch 42 has the same components as the hand switch 41, and consists of, for example, two pedal switches A and B. A foot switch connector 49 is linked to the foot switch 42 in the same manner as the hand switch connector linked to the hand switch 41. The foot switch connector 49 accommodates a line linking a contact 46a of the pedal switch A and a contact 46b of the pedal switch B, a line linked to a contact 47a of the pedal switch A, and a line linked to a contact 47b of the pedal switch B.

The extension unit 43 consists of two photocouplers 51a and 51b, a power source 52, and resistors R3 and R4. The photocouplers 51a and 51b electrically separate and isolate the hand switch 41 from the main unit 2 and transmit signals. The power source 52 supplies power to the photocouplers 51a

and 51b. The resistors R3 and R4 restrict a source current. The extension unit 43 has a hand switch connector portion 54 and a foot switch connector portion 55 formed thereon and has a joint connector 56 linked thereto. The hand switch connector 45 linked to the hand switch 41 is joined to the hand switch connector portion 54. The foot switch connector 49 linked to the foot switch 42 is joined to the foot switch connector portion 55. The joint connector 56 serves as a connecting means for connecting the extension unit to the main unit 2.

One of lines accommodated by the hand switch connector portion 54 is linked to the power source 52. One end of the line is linked to a light emitting diode D1 in the photocoupler 51a via the resistor R3, and returned to the hand switch connector portion 54 from the light emitting diode D1. The other end thereof is linked to a light emitting diode D2 of the photocoupler 51b via the resistor R4, and returned to the hand switch connector portion 54 from the light emitting diode D2.

The output terminal of a phototransistor Tr1 for receiving light emitted from the light emitting diode D1 of the photocoupler 51a is connected to the joint connector 56 to be joined to the main unit 2 and to the foot switch connector portion 55 to which the foot switch connector 49 linked to the foot switch 42 is joined. The output of a

phototransistor Tr2 for receiving light emitted from the light emitting diode D2 of the photocoupler 51b is also connected to the joint connector 56 and foot switch connector portion 55.

When the ultrasonic surgical apparatus having the foregoing components is employed, the scissors-like handpiece 3A is controlled with the treatment unit 16a of the scissors-like handpiece 3A abutted on a region to be treated in a living tissue.

For example, when the switch A or B of the hand switch 41 is pressed, the photocoupler 51a or 51b is actuated. This causes the switch sense circuit 31 in the main unit 2 to operate. Ultrasonic waves are output. When the pedal switch A or B of the foot switch 42 is stepped on, these components operate similarly. Since the hand switch and switch sense circuit are isolated from each other by the photocouplers 51a and 51b, it will not take place that a living tissue conducts via the hand switch 41. The living tissue is thus secured electrically.

Owing to the aforesaid components, the hand switch 41 and main unit 2 can be electrically separated from each other. The hand switch 41 can be used with a living tissue electrically secured more successfully than when a hand switch is used in combination with the circuits shown in FIG. 3.

In the ultrasonic surgical system of the present embodiment, the scissors-like handpiece 3A, hook-like handpiece 3B, and trocar and cannula-like handpiece 3C that are the first to third handpieces are freely detachably and selectively attached to the one main unit 2 in order to perform ultrasonic treatment. The present invention is not limited to this mode. Any handpiece other than the scissors-like handpiece 3A, hook-like handpiece 3B, and trocar and cannula-like handpiece 3C, for example, a handpiece for ultrasonically clipping an incised region by utilizing ultrasonic waves may be freely detachably attached to the main unit 2. Thus, ultrasonic treatment may be achieved.

FIG. 5 and FIG. 6 relate to the second embodiment of the present invention. FIG. 5 is an explanatory diagram schematically showing the configuration of an ultrasonic surgical system. The ultrasonic surgical system uses an ultrasonic surgical apparatus having a scissors-like handpiece, a hook-like handpiece, and a trocar and cannula-like handpiece, which are the first, second, and third handpieces, selectively connected to an extension unit so that they can be unconnected freely. FIG. 6 is a circuit block diagram of the ultrasonic surgical apparatus shown in FIG. 5.

In the first embodiment, the ultrasonic surgical system

1 is constructed based on the ultrasonic surgical apparatus 1A. Specifically, one of the scissors-like handpiece 3A, hook-like handpiece 3B, and trocar and cannula-like handpiece 3C that are the first, second, and third handpieces is selected and connected to the main unit 2 so that they can be unconnected freely. The hand switch 4 detachably attached to the flank of the operation unit of the handpiece is connected to the main unit via the extension unit 6. The hand switch 4 is pressed in order to control the handpiece.

In an ultrasonic surgical system 61 based on an ultrasonic surgical apparatus 61A in accordance with the present embodiment, the first to third handpieces and the hand switches 4 attached to the flanks of the operation units of the handpieces can be connected to the main unit 2 at the same time. In the present embodiment, the hand switches 4 are used selectively, and the handpieces connected to the main unit 2 are thus used for different purposes. The handpieces can be manipulated independently.

In the circuit block diagram of the ultrasonic surgical apparatus of FIG. 6, three lines accommodated in hand switch 4 and foot switch 5 respectively are integrated into one line. The same reference numerals are assigned to components identical to those shown in FIG. 1 to FIG. 3.

The ultrasonic surgical apparatus 61A of the present

embodiment consists of a main unit 62, a connector extension unit 63, a scissors-like handpiece 3A, a hook-like handpiece 3B, a trocar and cannula-like handpiece 3C, hand switches 4, and a foot switch. A means for driving an ultrasonic transducer that is not shown is incorporated in the main unit 62. The connector extension unit 63 is connected to the main unit 62. The scissors-like handpiece 3A, hook-like handpiece 3B, and trocar and cannula-like handpiece 3C that are the first to third handpieces are connected to connector joint portions 64a, 64b, and 64c formed on the connector extension unit 63 so that they can be unconnected freely. The hand switches 4 are detachably attached to the flanks of the operation units of the handpieces. The foot switch 5 is stepped on when selected instead of the hand switches 4.

The main unit 62 is connected to the connector extension unit 63 by way of cables 65a, 65b, and 65c serving as connecting means for transmitting a signal produced by the connector extension unit 63.

The connector extension unit 63 has hand switch connector portions 67a, 67b, and 67c, and three selection switches 68a, 68b, and 68c. The hand switch connectors 21 linked to the three hand switches 4 are joined to the hand switch connector portions 67a, 67b, and 67c. The selection switches 68a, 68b, and 68c serve as selecting means for selecting the three handpieces. Moreover, a foot switch

connector portion 69 to which the foot switch connector 22 linked to the foot switch 5 is joined is formed on the back side of the connector extension unit 63. The connector extension unit 63 has the cables 65a, 65b, and 65c extended therefrom. A signal produced by a generating means incorporated in the connector extension unit 63 is transmitted to the main unit 62 by way of the cables 65a, 65b, and 65c serving as connecting means.

Referring to FIG. 6, a description will be made of the circuitry of the ultrasonic surgical apparatus consisting of the scissors-like handpiece 3A, hook-like handpiece 3B, and trocar and cannula-like handpiece 3C, the connector extension unit 63, and the main unit. The scissors-like handpiece 3A, hook-like handpiece 3B, and trocar and cannula-like handpiece 3C serve as the first to third handpieces. Handpiece connectors 8a, 8b, and 8c linked to the handpieces, and the hand switch connectors 21 linked to the hand switches 4 detachably attached to the flanks of the operation units of the handpieces are coupled to the connector extension unit 63. The connector extension unit 63 is connected to the main unit 62. To begin with, the components of the main unit 62 will be described.

The main unit 62 consists mainly of a hand switch sense circuit 71, a foot switch sense circuit 72, a control unit 73, and an oscillator circuit 74. The hand switch sense

circuit 71 detects signals sent from the hand switches via the connector extension unit 63. The foot switch sense circuit 72 detects a signal sent from the foot switch 5 via the connector extension unit 63. The control unit 73 outputs a control signal according to signals sent from the switch sense circuit 71 and foot switch sense circuit 72. The oscillator circuit 74 drives the first to third handpieces according to a control signal sent from the control unit 73.

The connector extension unit 63 consists of a signal generating means, and the cables 65a, 65b, and 65c. The signal generating means generates signals to be transmitted to the three selection switches 68a, 68b, and 68c, which serve as selecting means, and to the main unit 62. The cables 65a, 65b, and 65c serve as transmitting means for transmitting the signals generated by the generating means to the main unit 62.

The generator consists of a control circuit 81, a output connector switching relay 82, and a switch sense circuit 83. The control circuit 81 gives control to supply an output of the oscillator circuit 74 in the main unit 62 to a handpiece selected with any of the selection switches 68a to 68c pressed. The output connector switching relay 82 supplies an output of the oscillator circuit 74 in the main unit to a selected handpiece under the control of the

control circuit 81. The switch sense circuit 83 senses manipulation signals stemming from the hand switches 4 or a manipulation signal stemming from the foot switch 5 via the hand switch connector portions 67a, 67b, and 67c or the foot switch connector portion 69. The switch sense circuit 83 then produces a signal to be transmitted to the main unit 62.

Assume that the ultrasonic surgical apparatus 61 having the foregoing components is employed. For example, when the selection switch 68a is pressed, the output connector switching relay 82 operates to select the connector joint portion 64a under the control of the control circuit 81. In this state, the switch A or B of the foot switch 5 is stepped on. The switch sense circuit 83 in the connector extension unit 63 senses a manipulation signal stemming from the foot switch 5. The foot switch sense circuit 72 in the main unit 62 senses by way of the cable 65b which of the switches A and B of the foot switch 5 has been stepped on. Based on a signal sent from the foot switch sense circuit 72, the control unit 73 controls activation or inactivation of the oscillator circuit 74. Consequently, power is supplied to the scissors-like handpiece 3A by way of the cable 65a, the output connector switching relay 82 in the connector extension unit 63, the connector joint portion 64a, and the handpiece connector 8a. Eventually, ultrasonic treatment is enabled.

Likewise, when the selection switch 68b is pressed, the output connector switching relay 82 operates to select the connector joint portion 64b under the control of the control circuit 81. Consequently, power is supplied to the hook-like handpiece 3B, and ultrasonic treatment is enabled.

In the above state, that is, when a handpiece to be used is selected by pressing any of the selection switches 68a to 68c, the hand switch 4 is pressed. The switch sense circuit 83 then senses which of the hand switches has been pressed. The information is transmitted to the control circuit 81, and the output connector switching relay 82 is actuated. Consequently, ultrasonic treatment can be performed using the selected handpiece.

The handpieces can be readily used for different purposes without the necessity of retrofitting the ultrasonic surgical apparatus 61A. The handpieces can be manipulated independently. This leads to improved maneuverability.

For selecting a handpiece, the selection switches 68a, 68b, and 68c of the connector extension unit 63 and the hand switches 4 may not be used. Instead, a voice recognition circuit (not shown) for recognizing voice may be included in the connector extension unit 63. A selecting means to be actuated based on the results of voice recognition performed by the voice recognition circuit may be used to select a

handpiece. The present invention is not limited to these modes.

FIG. 7 to FIG. 9 relate to the third embodiment. FIG. 7 is an explanatory diagram schematically showing the configuration of an ultrasonic surgical system based on an ultrasonic surgical apparatus having a scissors-like handpiece, a trocar and cannula-like handpiece, and a perfusion/suction handpiece connected to a connector extension unit so that they can be unconnected freely. The scissors-like handpiece, trocar and cannula-like handpiece, and perfusion/suction handpiece serve as the first, third and fourth handpieces. FIG. 8 is a circuit block diagram of the ultrasonic surgical apparatus shown in FIG. 7. FIG. 9 is a circuit block diagram of a modification of a perfusion/suction unit shown in FIG. 8.

In the second embodiment, the ultrasonic surgical system 61 is constructed based on the ultrasonic surgical apparatus 61A. Specifically, the selection switches 68a, 68b, and 68c of the connector extension unit 63 serving as selecting means, the foot switch 5, and the hand switches 4 are used selectively in order to utilize the plurality of handpieces for different purposes. Set values for the respective handpieces are manually input at the main unit 62. The set values, that is, an ultrasonic frequency or a power level are different from handpiece to handpiece.

Consequently, the handpieces can be manipulated mutually independently.

In the present embodiment, the selection switches 68 (68a, 68b, and 68c) of the connector extension unit 63 serving as selecting means, the foot switch 5, and the hand switches 4 are used selectively. The set values optimal to the respective handpieces are automatically set. Consequently, a selected handpiece is used to perform ultrasonic treatment.

In the ultrasonic surgical apparatus shown in FIG. 7, the scissors-like handpiece 3A serving as the first handpiece is an ultrasonic coagulation/incision appliance used to ultrasonically coagulate or incise a lesion. The scissors-like handpiece 3A is provided with a perfusion facility or a suction facility for perfusing a region to be treated in a living tissue or sucking a fluid from the region. Furthermore, a perfusion unit/suction unit is included as external units. Thus, perfusion or suction is performed. The other components are identical to those shown in FIG. 5 and FIG. 6. The description of the components will be omitted. The same reference numerals are assigned to components identical to those shown in FIG. 5 and FIG. 6.

As shown in FIG. 7, an ultrasonic surgical apparatus 100A for realizing an ultrasonic surgical system 100

consists of a main unit 101, a connector extension unit 102, a perfusion/suction unit 103, a scissors-like handpiece 3A, a trocar and cannula-like handpiece 3C, a perfusion/suction handpiece 3D, hand switches 4, and a foot switch 5. A means for driving an ultrasonic transducer that is not shown is incorporated in the main unit 101. The connector extension unit 102 is connected to the main unit 101 by way of a cable 101a and a cable 101b serving as connecting means. The perfusion/suction unit 103 is connected to the main unit 101 by way of the cable 101b and includes a perfusing means and a sucking means. The scissors-like handpiece 3A, trocar and cannula-like handpiece 3C, and perfusion/suction handpiece 3D serve as the first, third, and fourth handpieces and are connected to connector joint portions 64 (64a, 64b, and 64c) on the connector extension unit 102 so that they can be unconnected freely. The hand switches 4 are detachably attached to the flanks of the operation units of the handpieces 3A, 3C, and 3D. The foot switch 5 is stepped on when selected instead of the hand switches 4. Any other handpieces having different shapes from the above handpieces and designed for different purposes of use may be used in combination. The handpieces each have an ultrasonic transducer, which is not shown, incorporated therein.

A panel setting unit 111 serving as a setting means is formed on the front panel 7 of the main unit 101. The panel

setting unit 111 is used to set various set values based on which an ultrasonic transducer, which is not shown, incorporated in any of the scissors-like handpiece 3A, trocar and cannula-like handpiece 3C, and perfusion/suction handpiece 3D serving as the first, third, and fourth handpieces is driven. The foot switch connector 22 linked to the foot switch 5 is joined to the foot switch connector portion 69 of the main unit 101.

The perfusion/suction handpiece 3D serves as the fourth handpiece that is an ultrasonic suction appliance realized by appending a perfusion facility or a suction facility to the scissors-like handpiece 3A serving as the first handpiece that is an ultrasonic coagulation and incision appliance. The ultrasonic suction appliance pulverizes and emulsifies unnecessary cells of a living tissue by utilizing ultrasonic waves, and then sucks and removes the unnecessary cells. A perfusion channel and a suction channel that are not shown are formed inside the perfusion/suction handpiece 3D. A perfusion tube 104 and a suction tube 105 communicate with the perfusion channel and suction channel respectively. A region to be treated in a living tissue is perfused with a fluid poured through a perfusion port, which is not shown, formed in the treatment unit by way of the perfusion tube 104 and perfusion channel. A treated living tissue or humor is sucked through a suction port, which is not shown, formed

in the treatment unit by way of the suction tube 105 and suction channel.

The perfusion/suction unit 103 has a perfusion joint portion 106 and a suction joint portion 107 coupled to the perfusion tube 104 and suction tube 105 of the perfusion/suction handpiece 3D. Physiological saline or the like used to perfuse a region to be treated in a living tissue is supplied through the perfusion tube 104, or suction pressure used to suck a treated living tissue or humor is supplied through the suction tube 105.

Referring to FIG. 8, a description will be made of the circuitry of the ultrasonic surgical apparatus consisting of the scissors-like handpiece 3A, trocar and cannula-like handpiece 3C, and perfusion/suction handpiece 3D, connector extension unit 102, main unit 101, and perfusion/suction unit 103. The scissors-like handpiece 3A, trocar and cannula-like handpiece 3C, and perfusion/suction handpiece 3D serve as the first, third, and fourth handpieces. The handpieces and hand switches 4 are connected to the connector extension unit 102. The connector extension unit 102 is connected to the main unit 101. The perfusion tube 104 and suction tube 105 of the perfusion/suction handpiece 3D are coupled to the perfusion/suction unit 103. First, the main unit 101 will be described below.

The main unit 101 consists mainly of a panel setting

unit 112, a drive unit 113, and a control unit 113. The drive unit 113 serves as a driving means for properly driving an ultrasonic transducer that is not shown. The control unit 113 serves as a control means for controlling the drive unit 112 and panel setting unit 111.

The extension unit 102 consists mainly of a switching unit 121 and a switching control unit 122. The switching unit 121 serves as a distributing means for distributing a driving signal, which has been produced by the drive unit 112 in the main unit 101 and received by way of a cable 101a, to the handpieces. The switching control unit 122 controls the switching unit 121. The switching control unit 122 is connected to the selection switches 68. When any of the selection switches 68 is pressed, the switching unit 121 is controlled.

The perfusion/suction unit 103 consists mainly of a perfusion pump 131, a perfusion/suction control unit 132, a suction pump 133, a suction pressure control unit 134, and a perfusion/suction control unit 135. The perfusion pump 131 serves as a perfusing means for supplying physiological saline or the like through the perfusion joint portion 106 via the perfusion tube 104. The perfusion control unit 132 drives the perfusion pump 131. The suction pump 133 serves as a sucking means for sucking a treated living tissue or humor through the suction

tube 105. The suction pressure control unit 134 controls suction pressure. The perfusion/suction control unit 135 controls the perfusion control unit 132 and the suction pressure control unit 134.

The control unit 112 in the main unit 101 is connected to the switching control unit 122 in the connector extension unit 102 and the perfusion/suction control unit 135 in the perfusion/suction unit 103 over the cable 101b. The control unit 112 transfers information based on various set values set using the panel setting unit 111 to or from the switching control unit 122 and perfusion/suction control unit 135. The control unit 112 thus autonomously sets parameters suitable for a selected handpiece. Moreover, the connectors 8a, 8c, and 8d of the scissors-like handpiece 3A, trocar and cannula-like handpiece 3C, and perfusion/suction handpiece 3D serving as the first, third, and fourth handpieces are joined to the connector joint portions 64 (64a, 64b, and 64c) on the main unit 101. The different types of handpieces are thus identified mutually independently. A reporting means for identifying a handpiece may be incorporated in each of the connectors 8a, 8c, and 8d of the handpieces. In this case, the reporting means is identified using a judging means implemented in the control unit 112 in the main unit 101. Parameters suitable for a selected handpiece are thus automatically set.

Assuming that the ultrasonic surgical apparatus 100A having the foregoing components is employed. The handpieces 3A, 3C, and 3D are connected to the connector extension unit 102. For example, the hand switch 4 is pressed in order to select a handpiece to be used. The control unit 112 in the main unit 101 is changed over to the connector of the selected handpiece. At the same time, information of the selected type of handpiece is transmitted to the main unit 101. The control unit 112 in the main unit 101 receives the transmitted information. Parameters suitable for the selected handpiece are then transmitted to the drive unit 113 and set therein. At this time, when the perfusion/suction handpiece 3D is used to perform perfusion or suction, the information is sent to the perfusion/suction control unit 135 in the perfusion/suction unit 103. An amount of fluid to be supplied or a level of suction pressure is set properly. For example, for sucking a treated living tissue or humor, the suction control unit 134 sets an optimal suction pressure under the control of the perfusion/suction control unit 135, and drives the suction pump 133. Suction pressure is then supplied to the perfusion/suction handpiece 3D through the suction port 107 via the suction tube 105.

Consequently, selection information concerning a selected one of the plurality of handpieces is transmitted

from the main unit 101 to the connector extension unit 102 and perfusion/suction unit 103. Set values optimal to the selected handpiece are then set automatically.

FIG. 9 shows a modification of the perfusion/suction unit 103. Herein, the perfusion/suction unit 103 has a setting portion 140 used to set values concerning output of ultrasonic waves. When a handpiece used for perfusion or suction, for example, the perfusion/suction handpiece 3D is selected, values concerning output of ultrasonic waves set at the perfusion/suction unit 103 may be transmitted to the main unit 101 and thus validated. This is effective in a case where a handpiece usable both for ultrasonic coagulation or incision and for ultrasonic emulsification and suction is used in combination. Furthermore, the connector extension unit 102 may merely send a connector signal to the main unit 101. The main unit 101 may then judge the type of handpiece. The information may be sent from the main unit 101 to the connector extension unit 102 and perfusion/suction unit 103.

Consequently, the plurality of handpieces can be used for different purposes as components of one ultrasonic surgical apparatus. When a handpiece to be used is selected, set values optimal to driving of the handpiece can be set automatically but need not be set manually. The ultrasonic surgical system of the present embodiment can thus offer

more excellent maneuverability than the ultrasonic surgical system 61 of the second embodiment.

For selecting a handpiece, the selection switches 68a, 68b, and 68c on the connector extension unit 103 and the hand switches 4 may not be used. Instead, a voice recognition circuit (not shown) for recognizing voice may be incorporated in the connector extension unit 610. A selecting means actuated based on the results of voice recognition performed by the voice recognition circuit may be employed, too. The present invention is not limited to these modes.

FIG. 10 to FIG. 12 relate to the fourth embodiment of the present invention. FIG. 10 is an explanatory diagram schematically showing an ultrasonic surgical system in accordance with the fourth embodiment of the present invention. FIG. 11 shows the appearance of a handpiece having a built-in hand switch and being used when selected instead of a scissors-like handpiece shown in FIG. 10. FIG. 12 is a circuit block diagram of the handpiece.

An ultrasonic surgical system 201 of the present embodiment consists mainly of a main unit 202, a scissors-like handpiece 3A, an external hand switch 4, and a foot switch 205. A driving signal generator for generating a driving signal, which will be described later, is incorporated in the main unit 202. The scissors-like

handpiece 3A is connected to the main unit 202 so that it can be unconnected freely. An ultrasonic transducer that will be described later is incorporated in the scissors-like handpiece 3A. The external hand switch 4 can be freely detachably attached to the flank of the operation unit of the scissors-like handpiece 3A. The foot switch 205 is connected to the main unit 202 so that it can be unconnected freely. The foot switch 205 is used when selected instead of the hand switch 204.

A power switch 207, a display panel 208, a handpiece connector 209, and a hand switch connector 210 are formed on a front panel 206 of the main unit 202. The display panel 208 indicates a state of operation. The hand-piece connector 209 is connected to the scissors-like handpiece 3A. The external hand switch 204 is connected to the hand switch connector 210. A foot switch connector 205b (see FIG. 12) to which a foot switch plug 205a linked to the foot switch 205 is joined so that it can be unjoined freely is formed on a rear panel of the main unit 202.

The scissors-like handpiece 3A consists of an elongated sheath 211a, a handy operation unit 212a, and a treatment unit 213a. The operation unit 212a is coupled to the proximal end of the sheath 211a. The treatment unit 213a is located at the distal end of the sheath 211a. The scissors-like handpiece 3A has a handpiece plug 214a to be joined to

the handpiece connector 209 on the main unit 202.

An ultrasonic transducer that will be described later and a probe 215a are incorporated in the scissors-line handpiece 3A. The ultrasonic transducer generates ultrasonic waves. The probe 215a transmits ultrasonic waves output from the ultrasonic transducer to the treatment unit 213a. The treatment unit 213a has a clamping portion 216a supported so as to pivot freely at the distal end of the sheath 211a. The clamping portion 216a can be brought into contact with or separated from the distal part of the probe 215a. The operation unit 212a has a stationary handle 217a and a movable handle 218a. The movable handle 218a is opened or closed relative to the stationary handle 217a, whereby the clamping portion 216a of the treatment unit 213a can be brought into contact with or separated from the distal part of the probe 215a. In this case, when the movable handle 218a is closed, the clamping portion 216a is turned to close relative to the distal part of the probe 215a. The clamping portion 216a and the distal part of the probe 215a cooperate with each other in clamping a living tissue, for example, a blood vessel in a living body. The ultrasonic transducer in the scissors-like handpiece 3A is driven in this state, whereby the living tissue clamped by the probe 215a and the clamping portion 216a is ultrasonically coagulated or incised.

The external hand switch 204 is detachably attached to the handy operation unit 212a of the scissors-line handpiece 3A. The hand switch 204 consists of, for example, two switches A and B. The hand switch plug 219 to be joined to the hand switch connector 210 on the main unit 202 is linked to the proximal end of the hand switch 204.

Moreover, when selected instead of the scissors-like handpiece 3A, another scissors-like handpiece 3B shown in FIG. 11 can be connected to the hand switch connector 209 of the main unit 202 so that it can be unconnected freely. The scissors-like handpiece 3B has a built-in hand switch 220 that is incorporated in a handy operation unit 212b. The handpiece plug 214b accommodates a signal line extending from the built-in hand switch 220. The other components are identical to those of the scissors-like handpiece 3A.

In the present embodiment, an output switching means is included for switching output of a driving signal and non-output thereof according to a manipulation signal stemming from the external hand switch 204 or built-in hand switch 220. The driving signal is output from a driving means to the output port of the handpiece connector 209. Incidentally, a plurality of handpieces other than the scissors-like handpieces 3A and 3B may be connected to a plurality of handpiece connectors 209 on the main unit 202 at the same time. In this case, a switching means may be

included for switching connected states, in which the handpieces are connected to the plurality of handpiece connectors 209, into another states instead of the means for switching output of a driving signal to the output pins and non-output thereof.

Next, the circuitry of the ultrasonic surgical system 201 will be described in conjunction with FIG. 12.

The circuitry of the main unit 202 consists mainly of a drive circuit 232, a switch sense circuit 233, and a control circuit 234. The drive circuit 232 drives the ultrasonic transducer 231 incorporated in a handpiece such as the scissors-like handpiece 3A or 3B. The switch sense circuit 233 senses which of the external hand switch 204 and built-in hand switch 220 has been pressed. The control circuit 234 controls the drive circuit 232 and display panel 208 according to a signal sent from the switch sense circuit 233, a manipulation signal stemming from the foot switch 203, or a manipulation signal output from the front panel 206.

The handpiece plugs 214a and 214b linked to the scissors-like handpieces 3A and 3B can be joined to the handpiece connector 209 on the main unit 202. Referring to FIG. 12, the scissors-like handpiece 3B having the built-in hand switch 220 is connected to the main unit 202. The external hand switch 204 is connected to the hand switch connector 210 on the main unit 202.

The handpiece plug 214b accommodates, in addition to, a driving signal line 236 routed to the ultrasonic transducer 231, a signal line 237 extending from a hand switch.

In the main unit 202, a signal line 237 extending from the hand switch connector 209 and the signal line 237 extending from the hand switch to the handpiece connector 209 are laid down parallel to each other. The switch sense circuit 233 senses whichever of the external hand switch 204 and built-in hand switch 220 has been pressed, and transmits a signal stemming from the pressed switch to the control circuit 234. The control circuit 234 actuates the drive circuit 232. Thus, output of a driving signal is controlled in order to activate or inactivate the ultrasonic transducer 231. Moreover, the control circuit 234 uses the display panel 208 to indicate a handpiece and a hand switch, which are currently in use, according to a signal sent from the switch sense circuit 233.

When the ultrasonic surgical system 201 having the foregoing components is employed, the scissors-like handpiece 3B is controlled with the treatment unit 231a thereof abutted on a region to be treated in a living tissue. The scissors-like handpiece 3B has the built-in hand switch 220. Incidentally, the scissors-like handpiece 3A may be connected to the main unit 202 instead of the scissors-like handpiece 3B.

For example, the switch A or B of the built-in hand switch 220 is pressed. A manipulation signal stemming from the built-in hand switch 220 is then transmitted to the switch sense circuit 231 in the main unit 2. It is then sensed that the switch A or B of the built-in hand switch 220 has been pressed. Based on the sensed manipulation signal, the control circuit 232 controls the drive circuit 232 to control output of a driving signal. The currently used built-in hand switch 220 is indicated using the display panel 208 under the control of the control circuit 232.

There is a case where the external hand switch 204 must be used for the sake of operation. For example, an operator cannot release a handpiece and therefore has to instruct a nurse or the like to switch on or off the handpiece. In this case, the external hand switch 204 is connected to the main unit 202 and thus put to use.

When the switch A or B of the external hand switch 204 is pressed, a manipulation signal stemming from the external hand switch 204 is transmitted to the switch sense circuit 231 in the main unit 202. It is then sensed that the external hand switch 204 has been pressed. Based on the sensed manipulation signal, the control circuit 232 controls the drive circuit 232 and thus controls output of a driving signal. The currently used external hand switch 204 is indicated on the display panel 208 under the control of the

control circuit 232. On the contrary, the external hand switch 4 may be connected to the main unit 202 in advance, and the built-in hand switch 220 may be pressed in order to control output of the driving signal.

Consequently, whichever of the built-in hand switch 220 and external hand switch 204 is used, the ultrasonic surgical system can be actuated. It can be checked which of the hand switches is used to control output of a driving signal.

This results in the ultrasonic surgical system offering improved maneuverability and enabling remote control despite the simple configuration.

FIG. 13 to FIG. 16 relate to the fifth embodiment of the present invention. FIG. 13 is an explanatory diagram schematically showing the configuration of an ultrasonic surgical system in accordance with the fifth embodiment of the present invention. FIG. 14 is a circuit block diagram of the ultrasonic surgical system shown in FIG. 13. FIG. 15 is a flowchart describing a sequence of selecting a connector on an extension unit. FIG. 16A to FIG. 16C are explanatory diagrams showing the internal wirings of hand switches. FIG. 16A is an explanatory diagram showing the internal wiring of a hand switch consisting of two output switches A and B. FIG. 16B is an explanatory diagram showing the internal wiring of a hand switch having a

selection switch added to the two output switches A and B shown in FIG. 16A. FIG. 16C is an explanatory diagram showing the internal wiring of a hand switch having only the selection switch shown in FIG. 16B.

In the fourth embodiment, the ultrasonic surgical system 201 has one selected handpiece connected to the main unit 202 so that the handpiece can be unconnected freely. The external hand switch attached to the flank of the operation unit of the handpiece or the built-in hand switch 220 is pressed in order to control the handpiece.

By contrast, in the fifth embodiment, an extension unit 253 is used to enable simultaneous connection of a plurality of handpieces. The external hand switch 204 or built-in hand switch 220 is manipulated in order to select a handpiece employed.

As shown in FIG. 13, an ultrasonic surgical system 251 of the fifth embodiment consists mainly of a main unit 252, an extension unit 253, a scissors-like handpiece 3A, a hook-like handpiece 3C, a trocar and cannula-like handpiece 3D, external hand switches 255, a foot switch 256, and a remote switch 257. A driving signal generator for generating a driving signal that will be described later is incorporated in the main unit 252. The driving signal output from the driving signal generator in the main unit 252 is supplied to the extension unit 253. The scissors-like handpiece 3A,

hook-like handpiece 3C, and trocar and cannula-like handpiece 3D are connected to output ports 254a, 254b, and 254c mounted on the extension unit 253 so that they can be unconnected freely. The external hand switches 255 can be freely detachably attached to the flanks of the operation units of the handpieces. The foot switch 256 is stepped on when selected instead of the hand switches 255. The remote switch 257 is connected to the extension unit 253 so that it can be unconnected freely, and used to remotely select any of the output ports 254a, 254b, and 254c.

The scissors-like handpiece 3A, hook-like handpiece 3C, and trocar and cannula-like handpiece 3D have handpiece plugs 214a, 214c, and 214d linked thereto. The handpiece plugs 214a, 214c, and 214d are joined to the output ports 254a, 254b, and 254c. One of the handpieces can be used when selected. Moreover, a handpiece having the built-in hand switch 220 described in relation to the fourth embodiment may be connected to the extension unit 253 so that it can be unconnected freely.

A power switch 262, a display panel 263, and a hand switch connector 264 are formed on a front panel 261 of the main unit in the same manner as they are in the fourth embodiment. The display panel 263 indicates an operating state. The hand switch connector 264 is used to connect the external hand switch 255 so that the external hand switch

can be unconnected freely. A foot switch connector 246b (see FIG. 14) to which a foot switch plug 256a linked to the foot switch 256 can be joined so that it can be unjoined freely is formed on the rear panel (not shown) of the main unit 252. Moreover, an output port 252a of the main unit 252 is connected to an input port 253a of the extension unit 253 by way of a connection cord 265 (see FIG. 14). A driving signal that is output from a driving means in the main unit 252 is supplied by way of the output port 252a, connection cord 265, and input port 253a.

Connectors 271, 272, and 273, selection switches 274, 275, and 276, a loudspeaker 277, and a remote switch connector 278 are mounted on the extension unit 253. The connectors 271, 272, and 273 have the same ability as the hand switch connector 264 on the main unit 252, and are used to connect the hand switches 255 in such a manner that the hand switches 255 can be unconnected freely. The selection switches 274, 275, and 276 are used to manually select one of the output ports 254a, 254b, and 254c. The loudspeaker 277 reports a selected handpiece and hand switch by uttering a sound. The remote switch plug 257a linked to the remote switch 257 is joined to the remote switch connector 278 (see Fig. 14) so that it can be unjoined freely.

In the present embodiment, a driving signal output from the driving signal generator in the main unit 252 is output

to any of the output ports 254a, 254b, and 254c of the extension unit 253 which is selected using a switching unit included in the extension unit 253 according to a manipulation signal stemming from any of the external hand switches 255 and remote switch 257.

Next, the circuitry of the ultrasonic surgical system of the fifth embodiment will be described in conjunction with FIG. 14.

The circuitry and ability of the main unit 252 are identical to those of the main unit 202 described in conjunction with FIG. 12. The main unit 252 consists mainly of a drive circuit 281, a switch sense circuit 282, a display panel 283, and a control circuit 284.

The circuitry of the extension unit 253 consists mainly of a relay 285 for switching the output ports 254a, 254b, and 254c of the extension unit 253 and linking a selected one to a signal line and a control circuit 286 for controlling the relay 285 according to a manipulation signal stemming from any of the built-in hand switch 220, external hand switches 255, and remote switch 257.

The control circuit 286 has a latch or memory that is not shown. When an output port is selected, information of the selected output port is stored in the latch or memory until another output port is selected.

In the drawing, the scissors-like handpiece 3A, the

scissors-like handpiece 3B having the built-in hand switch 220, the external switches 255, and the remote switch 257 are connected to the extension unit 253.

Any of the built-in hand switch 220, external hand switches 255, and remote switch 257 is pressed in order to select any of the output ports 254a, 254b, and 254c. A manipulation signal stemming from pressing of a switch is input to the control circuit 286 in the extension unit 253. The control circuit 286 controls the relay 285 to close a contact thereof linked to the selected output port. The manipulation signal is also transmitted to the switch sense circuit 282 in the main unit 252.

Moreover, the built-in hand switch 220 and external hand switches 255 make only a selected handpiece, which is associated therewith, usable, and have two abilities to switch output of a signal and non-output thereof and select an associated handpiece. This is complicated. When both the switches A and B of a hand switch are pressed at the same time, a signal selecting an output port is output. When either the switch A or B thereof is pressed, a manipulation signal is output to switch output of a driving signal and non-output thereof. More particularly, when both the switches A and B of the built-in hand switch 220 or any of the external hand switches 255 are pressed at the same time, a signal for selecting any of the output ports 254a,

254b, and 254c is output. When either the switch A or B of a switch is pressed, if the switch is associated with an already selected output port, a manipulation signal is output for switching output of a driving signal and non-output thereof.

When any of the output ports 254a, 254b, and 254c is selected, which of the output ports has been selected is indicated using the display panel 208 under the control of the control circuit 286. However, an operator may stand at a position at which he/she cannot see the display panel clearly. As a means for checking which of the output ports has been selected, the control circuit 286 produces a sound and drives the loudspeaker 277 to utter the sound. For example, the sound is uttered once when the output port 254a is selected, and uttered twice when the output 245a is selected.

In the case of the ultrasonic surgical system 250 having the foregoing components, similarly to that of the fourth embodiment, ultrasonic treatment is performed with, for example, the treatment unit 213b of the scissors-like handpiece 3B having the built-in hand switch 220 abutted on a region to be treated in a living tissue.

Any of the built-in hand switch 220, external hand switches 255, and remote switch 257 is pressed in order to select an output port.

Referring to FIG. 15, a description will be made of a sequence of selecting an output port using any of the built-in hand switch 220 and external hand switches 255.

For example, both the switches A and switch B of the built-in hand switch 220 are pressed simultaneously, a signal is input to the control circuit 286 in the extension unit 253. It is thus sensed that the switch A and switch B have been pressed simultaneously (step S1). Control is then given to select the output port 254a (step S2).

For controlling selection, a signal used to select the output port 254a is transmitted to the switch sense circuit 282 in the main unit 252. The relay 285 is controlled to close a contact thereof linked to the selected output port 254a.

The currently employed scissors-like handpiece 3B and built-in hand switch 220 are indicated using the display panel 283 under the control of the control circuit 234 in the main unit 252. The selected output port 254a is reported using a sound uttered from the loudspeaker 277 under the control of the control circuit 286 in the extension unit 253 (step S3).

Assume that the switch A and switch B of a hand switch are not pressed simultaneously but the selection switch 274 on the front panel 271 of the extension unit 253 is pressed. A signal is then input to the control circuit 286 in the

extension unit 253. It is sensed that the selection switch 274 has been pressed (step S4). Control is then given to select the output port 254a (step S2). The selected output port 254a is then reported (step S3).

When a selection switch of the remote switch 257 associated with the output port 254a is pressed, similarly to when the selection switch 274 on the extension unit 253 is pressed, it is sensed that the selection switch has been pressed (step S5). Control is then given to select an output port (step S2), and the selected output port is reported (step S3).

By contrast, when either the switch A or switch B of the built-in hand switch 220 is pressed, a signal is input to the control circuit 286 in the extension unit 253. It is sensed that the switch A or switch B has been pressed (step S6 or step S7). If the switch A or switch B is associated with the already selected output port 254a (step S8), the signal stemming from the pressed switch A or switch B is transmitted to the main unit 252 (step S9).

When the output port 254a is selected, a driving signal output from the drive circuit 281 in the main unit 252 is transmitted to the scissors-like handpiece 3B through the selected output port 254a. Consequently, ultrasonic treatment can be performed.

Consequently, an operator engaged in an operation

selects a handpiece he/she wants to use. This leads to improved maneuverability. Besides, the operator can concentrate on the operation. Moreover, when the built-in hand switch 220 is manipulated in order to select a handpiece, the abilities to switch output of a signal and non-output thereof and to select an output port can be used on different occasions without the necessity of increasing the number of lines extending from hand switches. This leads to excellent maneuverability. Furthermore, an operator may stand at a position at which he/she cannot see the display panel 263 of the main unit 252, and therefore may not be able to discern the results of switching output ports. Nevertheless, the operator will be aware of which of the output ports has been selected owing to utterance of a sound. This leads to further improved maneuverability.

The hand switches employed in the ultrasonic surgical system have the wirings shown in FIG. 16A to FIG. 16C.

A hand switch 301 shown in FIG. 16A consists of switches A and B used to enable and disable output.

In comparison with the hand switch 301, a hand switch 302 shown in FIG. 16B is of a type having a selection switch S added to the two output switches A and B. When the switch S is pressed, the switches A and B are turned on simultaneously. The switch S thus acts as a selection switch for selecting an output port with both the switches A

and B pressed simultaneously.

The hand switches 301 and 302 have two abilities to switch output of a signal and non-output thereof and to select an output port. Depending on a handpiece, the built-in hand switch 220 may be used to switch output of a signal and non-output thereof, and another switch such as a foot switch may be used to select an output port. In this case, a hand switch 303 having only the selection switch S as shown in FIG. 16C would prove useful.

In the present invention, it is apparent that a wide range of different embodiments can be constructed based on the invention without a departure from the spirit and scope of the invention. This invention will be limited by the appended claims but not restricted by any specific embodiments.